

Label 26
porosity in the range of about 70% to 98% within said polymeric support,
at least one ion exchange resin filling said microstructure such that said composite
membrane is air impermeable, said composite membrane having a thickness of at most 0.8 mils
and an ionic conductance rate of at least 5.1 μ mhos/min.

100 ~~101~~. The composite membrane of claim ~~100~~⁹⁹, wherein said polymeric support is a polyolefin.

101 ~~102~~. The composite membrane of claim ~~100~~⁹⁹, wherein said polymeric support is a fluorinated
polymer.

102 ~~103~~. The composite membrane of claim ~~100~~⁹⁹, wherein said polymeric support is a chlorinated
polymer.

103 ~~104~~. The composite membrane of claim ~~102~~¹⁰¹, wherein said fluorinated polymer is
polytetrafluoroethylene.

104 ~~105~~. The composite membrane of claim ~~104~~¹⁰³, wherein said polytetrafluoroethylene is expanded
polytetrafluoroethylene.

105 ~~106~~. The composite membrane of claim ~~100~~⁹⁹, wherein said polymeric support is a polyamide.

106 ~~107~~. The composite membrane of claim ~~100~~⁹⁹, wherein said polymeric support is a
polycarbonate.

Rule 126

107 ~~108~~. The composite membrane of claim ~~102~~¹⁰¹, wherein said microstructure includes nodes interconnected with fibrils.

108 ~~109~~. The composite membrane of claim ~~104~~¹⁰³, wherein said microstructure includes nodes interconnected with fibrils.

109 ~~110~~. The composite membrane of claim ~~100~~⁹⁹, wherein the thickness of said composite membrane is in the range of between 0.06 and 0.8 mils.

110 ~~111~~. The composite membrane of claim ~~100~~⁹⁹, wherein the thickness of said composite membrane is in the range of between about 0.5 and 0.8 mils.

111 ~~112~~. The composite membrane of claim ~~100~~⁹⁹, wherein the thickness of said composite membrane is at most 0.5 mils.

112 ~~113~~. The composite membrane of claim ~~100~~⁹⁹, wherein said at least one ion exchange resin comprises a mixture of ion exchange resins.

113 ~~114~~. The composite membrane of claim ~~100~~⁹⁹, wherein said at least one ion exchange resin comprises a perfluorinated sulfonic acid resin.

114 ~~115~~. The composite membrane of claim ~~100~~⁹⁹, wherein said at least one ion exchange resin comprises a perfluorinated carboxylic acid resin.

115 ⁹⁹ 116. The composite membrane of claim ~~100~~, wherein said at least one ion exchange resin comprises a polyvinyl alcohol.

116 ⁹⁹ 117. The composite membrane of claim ~~100~~, wherein said at least one ion exchange resin comprises a divinyl benzene resin.

117 ⁹⁹ 118. The composite membrane of claim ~~100~~, wherein said at least one ion exchange resin comprises a styrene-based polymer.

118 ⁹⁹ 119. The composite membrane of claim ~~100~~, wherein said at least one ion exchange resin further comprises metal salts with or without a polymer.

BTQ
copy 119 ¹¹² 120. The composite membrane of claim ~~113~~, wherein said mixture of ion exchange resins includes at least two of a perfluorinated sulfonic acid resin, a perfluorinated carboxylic acid resin, a polyvinyl alcohol resin, a divinyl benzene resin or a styrene-based polymer.

120 ⁹⁹ 121. The composite membrane of claim ~~100~~, wherein said at least one ion exchange resin is a perfluorosulfonic acid/tetrafluoroethylene copolymer resin.

121 ⁹⁹ 122. The composite membrane of claim ~~100~~, further comprising a reinforcement backing bonded to a side thereof.

Rule

~~122 123.~~ An integral substantially air occlusive integral composite membrane having a polymeric support with a microstructure of pores, said microstructure filled with an ion exchange resin, said composite membrane has an ionic conductance rate of at least 5.1 $\mu\text{mhos/min}$, said composite membrane prepared by,

- ~~(a) providing a polymeric support having a microstructure of micropores;~~
- ~~(b) sequentially applying an ion exchange resin solution to each major surface of said polymeric support; and~~
- ~~(c) repeating step (b) until said micropores are sufficiently filled with ion exchange resin to form an air occlusive integral composite membrane.~~

DR
Carter

~~123 124.~~ The composite membrane of claim ~~123~~¹²², wherein said step (b) further includes,
(b1) drying said support after each application of ion exchange resin solution to remove solvent from said solution.

~~124 125.~~ The composite membrane of claim ~~123~~¹²², wherein said step (b) includes at least three successive applications of said ion exchange resin solution.

~~125 126.~~ The composite membrane of claim ~~123~~¹²², wherein said step (b) includes at least four successive applications of said ion exchange resin solution.

~~126 127.~~ The composite membrane of claim ~~123~~¹²², wherein said step (b) includes at least three

Rule 126

successive applications of said ion exchange resin solution, each followed by a drying step.

127 ~~128~~. The composite membrane of claim ¹²²~~123~~, wherein said step (b) includes at least four successive applications of said ion exchange resin solution, each followed by a drying step.

128 ~~129~~. The composite membrane of claim ¹²²~~123~~, wherein said support comprises a polyolefin.

129 ~~130~~. The composite membrane of claim ¹²²~~123~~, wherein said support comprises a fluorinated polymer.

130 ~~131~~. The composite membrane of claim ¹²²~~123~~, wherein said support comprises a chlorinated polymer.

131 ~~132~~. The composite membrane of claim ¹²⁹~~130~~, wherein said fluorinated polymer is polytetrafluoroethylene.

132 ~~133~~. The composite membrane of claim ¹³¹~~132~~, wherein said polytetrafluoroethylene is expanded polytetrafluoroethylene.

133 ~~134~~. The composite membrane of claim ¹²²~~123~~, wherein said support comprises a polyamide.

134 ~~135~~. The composite membrane of claim ¹²²~~123~~, wherein said support comprises a polycarbonate.

135 ~~136~~. The composite membrane of claim ¹²⁹~~130~~, where said microstructure includes nodes

interconnected with fibrils.

136 137. The composite membrane of claim ¹²²123, having a thickness in the range between 0.06 and 0.8 mils.

137 138. The composite membrane of claim ¹³⁶137, having a thickness in the range of between about 0.5 and at most 0.8 mils.

138 139. The composite membrane of claim ¹³⁶137, having a thickness of at most about 0.5 mils.

139 140. The composite membrane of claim ¹²²123, wherein said ion exchange resin is a mixture of resins.

140 141. The composite membrane of claim ¹²²123, wherein said ion exchange resin is a perfluorinated sulfonic acid resin.

141 142. The composite membrane of claim ¹²⁶127, wherein said drying is conducted at about room temperature.

142 143. The composite membrane of claim ¹²²123, wherein said ion exchange resin solution is applied in the presence of a surfactant.

143 144. The composite membrane of claim ¹²³124, wherein said ion exchange resin solution is

Rule 126
applied in the presence of a surfactant.

- 144 145. A method of preparing a substantially air occlusive integral composite comprising:
- (a) providing a polymeric support having a microstructure of micropores;
 - (b) sequentially applying an ion exchange resin solution to each major surface of said polymeric support; and
 - (c) repeating step (b) until said micropores are sufficiently filled with ion exchange resin to form an air occlusive integral composite membrane which has an ionic conductance rate of at least 5.1 $\mu\text{mhos/min}$.
- 145 146. The method of claim 145, wherein said step (b) includes at least three successive applications of said ion exchange resin solution.
- 146 147. The method of claim 145, wherein said step (b) includes at least four successive applications of said ion exchange resin solution.
- 147 148. The method of claim 145, wherein said step (b) includes at least two successive applications of said ion exchange resin solution, each followed by a drying step.
- 148 149. The method of claim 145, wherein said step (b) includes at least three successive applications of said ion exchange resin solution, each followed by a drying step.

149¹⁴⁴ 150. The method of claim ~~145~~¹⁴⁴, wherein said providing step (a) comprises providing as said polymeric support a polyolefin support.

150¹⁴⁴ 151. The method of claim ~~145~~¹⁴⁴, wherein said providing step (a) comprises providing as said polymeric support a fluorinated polymer support.

151¹⁴⁴ 152. The method of claim ~~145~~¹⁴⁴, wherein said providing step (a) comprises providing as said polymeric support a chlorinated polymer support.

152¹⁵⁰ 153. The method of claim ~~151~~¹⁵⁰, wherein said fluorinated polymer is polytetrafluoroethylene.

153¹⁵² 154. The method of claim ~~153~~¹⁵², wherein said polytetrafluoroethylene is expanded polytetrafluoroethylene.

154¹⁴⁴ 155. The method of claim ~~145~~¹⁴⁴, wherein said providing step (a) comprises providing as said polymeric support a polyamide.

155¹⁴⁴ 156. The method of claim ~~145~~¹⁴⁴, wherein said providing step (a) comprises providing as said polymeric support a polycarbonate support.

156¹⁴⁴ 157. The method of claim ~~145~~¹⁴⁴, where said microstructure includes nodes interconnected with fibrils.

157 ~~158~~. The method of claim ¹⁴⁴145, wherein said composite membrane has a thickness within the range of 0.06 to 0.8 mils.

158 ~~159~~. The method of claim ¹⁴⁴145, wherein said composite membrane has a thickness within the range of 0.5 to 0.8 mils.

131 ~~160~~. The method of claim ¹⁴⁴145, wherein said composite membrane has a thickness of at most 0.5 mils.

160 ~~161~~. The method of claim ¹⁴⁴145, wherein said ion exchange resin is a mixture of resins.

161 ~~162~~. The method of claim ¹⁴⁴145, wherein said ion exchange resin is a perfluorinated sulfonic acid resin.

162 ~~163~~. The method of claim ¹⁴⁵146, wherein said at least three successive applications of said ion exchange solution include alternate applications of said resin solution to a first side of said support and then to a second side of said support.

163 ~~164~~. A fuel cell including an ultra-thin, air impermeable integral composite membrane;
said composite membrane comprising:
a polymeric support having a microstructure of micropores, said microstructure defining a porosity in the range of about 70% to 95% within said polymeric support,

Rule 126
at least one ion exchange resin filling said microstructure such that said composite membrane is air impermeable, said composite membrane having a thickness of at most 0.8 mils.

163
164 ~~165~~. The fuel cell of claim ~~164~~, wherein said polymeric support is a fluorinated polymer.

164 ~~165~~. The fuel cell of claim ~~165~~, wherein said fluorinated polymer is polytetrafluoroethylene.

163
166 ~~167~~. The fuel cell of claim ~~164~~, wherein said microstructure includes from nodes interconnected with fibrils.

163
167 ~~168~~. The fuel cell of claim ~~164~~, wherein said composite membrane has a thickness in the range of between 0.06 and at most 0.8 mils.

167
168 ~~169~~. The fuel cell of claim ~~168~~, wherein said composite membrane has a thickness of at most 0.5 mils.

167
169 ~~170~~. The fuel cell of claim ~~168~~, wherein said at least one ion exchange resin comprises a mixture of ion exchange resins.

163
170 ~~171~~. The fuel cell of claim ~~164~~, wherein said at least one ion exchange resin comprises a perfluorinated sulfonic acid resin.

171 ~~172~~. The method according to claim ~~145~~¹⁰⁹, wherein step (b) is performed in the presence of a surfactant.

~~172~~¹⁰⁹ 173. The composite membrane of claim ~~110~~¹⁰⁹, wherein the thickness of said composite membrane is at most 0.4 mils.

~~173~~¹⁰⁹ 174. The composite membrane of claim ~~110~~¹⁰⁹, wherein the thickness of said composite membrane is at most 0.3 mils.

~~174~~¹⁰⁹ 175. The composite membrane of claim ~~110~~¹⁰⁹, wherein the thickness of said composite membrane is at most 0.2 mils.

~~175~~¹⁰⁹ 176. The composite membrane of claim ~~110~~¹⁰⁹, wherein the thickness of said composite membrane is at most 0.1 mils.

~~176~~¹³⁶ 177. The composite membrane of claim ~~137~~¹³⁶, wherein the thickness of said composite membrane is at most 0.4 mils.

~~177~~¹³⁶ 178. The composite membrane of claim ~~137~~¹³⁶, wherein the thickness of said composite membrane is at most 0.3 mils.

~~178~~¹³⁶ 179. The composite membrane of claim ~~137~~¹³⁶, wherein the thickness of said composite membrane is at most 0.2 mils.

136
180. The composite membrane of claim 137, wherein the thickness of said composite membrane is at most 0.1 mils.

144
181. The composite membrane of claim 145, wherein said step (b) further includes, (b1) drying said support after each application of ion exchange resin solution to remove solvent from said solution.

157
182. The composite membrane of claim 158, wherein the thickness of said composite membrane is at most 0.4 mils.

157
183. The composite membrane of claim 158, wherein the thickness of said composite membrane is at most 0.3 mils.

157
184. The composite membrane of claim 158, wherein the thickness of said composite membrane is at most 0.2 mils.

157
185. The composite membrane of claim 158, wherein the thickness of said composite membrane is at most 0.1 mils.

167
186. The composite membrane of claim 168, wherein the thickness of said composite membrane is at most 0.4 mils.